Bringing Nature Indoors and Online: Teaching Ecological Literacy and Fostering Pro-Environmental Attitudes and Behaviors During a Pandemic

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ABSTRACT

Environmental Education (EE) is a form of teaching that aims to increase students' ecological literacy, which is a person's overall understanding of the environment, its processes and its corresponding issues. In the United States there is no federal requirement for EE within public schools, making it increasingly clear that there is a need for increased access to EE as well as more research on its impacts and effectiveness. This research investigates the efficacy of online EE during a global pandemic on the pro-environmental knowledge, attitudes, and behavior changes within fifth grade students. The authors of this paper designed and taught a six-lesson EE curriculum to a fifth grade science class over the course of six weeks. In order to measure changes in environmental knowledge, the treatment group and a control group took a pretest before the lessons began and an identical posttest two weeks after the lessons' completion. To measure changes in environmental attitudes and behaviors, two student focus groups with 15 students total, one teacher interview, and two semi-structured interviews with treatment group parents were conducted. Findings showed the treatment group's environmental knowledge scores improved by over 65%, while the control group scores improved by less than 7%. Qualitative data reports that the online EE curriculum enhanced pro-environmental attitudes and behaviors as well as awareness surrounding environmental issues. Intergenerational learning took place within the households of treatment group students, but may have been stifled due to social limitations as a result of the Coronavirus pandemic. Experiential learning, involving hands-on, activity-based lessons, were the most effective tools for teaching online ecological literacy.

INTRODUCTION

The world is currently facing a number of social, economic, and environmental issues relating to humans' relationship with the planet, many of which have been amplified by the global Coronavirus pandemic. With the world's population at 7.8 billion people in 2020, and projected to be 9 billion by 2050, the pressures caused by human/environment interactions are exponentially increasing (Population Reference Bureau, 2020). The need for new thoughts and approaches to improve people's interactions with nature is crucial in sustaining a healthy environment and safety for future generations of all species. (Hollweg, et al., 2011).

Environmental education (EE) is a multidisciplinary field that has been used to foster informed citizenry, creating a society better equipped with tools and knowledge to solve pressing environmental problems (Smyth, 2006). Rapid global urbanization and technological advances have increasingly removed people from their connections to the natural environment (Strapp, 1997). The COVID-19 pandemic has further isolated people, many of whom remain indoors at home (including school-aged children), thus presenting the need for new pedagogical approaches to teaching environmental education in an increasingly challenging and complex world.

Broadly speaking, environmental education is "aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, and

motivated to work towards their solution" (Strapp et al., 1969, p.34). The practice of environmental education is expanding in the United States due to the adoption of the Next Generation Science Standards (NGSS) by many states, which incorporate a greater emphasis on human/environment interactions and place-based experiential education (Coyle, 2014). While there is a vast body of empirical peer-reviewed research on the outcomes of EE (environmental knowledge, attitudes, and behaviors) of children, adolescents, and adults, there is little current research on the outcomes of environmental education in the time of COVID-19, and how the switch to online learning, specifically online EE, has affected these outcomes, as well as students' relationships with the environment. The purpose of this mixed methods case study was to better understand the multiplicity of outcomes of designing and teaching an online multidisciplinary environmental education curriculum to fifth graders, using contemporary online education pedagogies focused on bolstering ecological literacy and pro-environmental attitudes and behaviors. We partnered with a 5th grade science class (a teacher and 15 students) at an independent elementary school in Upstate New York to teach an online environmental education curriculum. The goal of the curriculum was to use place-based education (PBE) and experiential learning (EXL) to increase students' knowledge about local ecosystems and the natural world, as well as to increase their pro-environmental behaviors and interest in environmental stewardship.

This research incorporated pretests and posttests, measuring the environmental knowledge of a treatment group and a control group. Both groups consisted of fifth grade science classes at two different private elementary schools. Both groups took the same pretest and posttest within the same week of one another, but the control group did not receive the environmental education 6-lesson curriculum. Qualitative research was also conducted within the treatment group through focus groups with the students, and semi-structured interviews with the primary teacher and two of the treatment group students' parents. Interviews were utilized to better understand the effectiveness of the EE curriculum in changing pro-environmental behaviors within the treatment group students, both at school and at home, as well as to document the multiplicity of outcomes and experiences of students engaged in the online learning curriculum.

Due to COVID-19, this environmental education curriculum was taught online while the students were gathered in person, together, in their classroom. Teaching methods included live lectures, games and activities, group work, and videos.

LITERATURE REVIEW

History of EE

In the early 18th century Jean-Jacques Rousseau stressed the importance of environmental education in creating a well-rounded and informed citizen in any nation state (McCrea, 2006). More contemporary EE gained significant footing in mainstream education

during the early 1970s. President Richard Nixon kick-started federally administered EE in the United States with the passage of the National Environmental Policy Act (NEPA) in January 1970. This act had widespread national impacts, establishing the Council on Environmental Quality (CEQ), the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA), and led to the passage of the National Environmental Education Act (NEEA). NEEA established an Office of Environmental Education (OEE) within the EPA, whose job was to facilitate and develop EE curriculum for US schools across the country. The OEE was also assigned with training environmental educators and distributing grants to projects developing and promoting EE (EETAP, 2002). Most recently in 2013, the practice of EE has expanded in the United States due to the adoption of the Next Generation Science Standards (NGSS) by many states, which incorporate a greater emphasis on human/environment interactions and place-based experiential education (Coyle, 2014).

The Industrial Revolution significantly shifted the US population from primarily rural farmers to urban dwellers. In 1790, only one out of 20 citizens lived in an urban area; however, today, almost 80% of the total population lives in or around urbanized areas (US Census, 2010). William B. Strapp, a founder of contemporary EE, highlights this, stating in 1997, "Within the past 50 years United States has become increasingly urbanized...As man became progressively urbanized his intimate association and interaction with them [nature] diminished, and with it his awareness of his dependency on them" (Strapp, 1997, p.33). Humans who for millennia lived under the stars and amongst the trees now find themselves in entirely manmade environments. Within the modern urban environment, humans are dissociated with many things that are fundamental to life, from where their food comes from to what happens to their waste. Today, a large portion of US society does not understand their actual ecological impact, further exacerbating environmental issues.

To counter these ever pressing issues, it is crucial to teach humans about their impact so they can make better, more sustainable decisions. David W. Orr defines a person's overall knowledge of environmental systems and subjects as ecological literacy. "Ecological literacy presumes both an awareness of the interrelatedness of life and knowledge of how the world works as a physical system" (Orr, 1992, p.92). Orr continues by saying "that ecological literacy is becoming more difficult, I believe, not because there are fewer books about nature, but because there is less opportunity for the direct experience of it" (Orr. 1992, p.89). With widespread urbanization and environmental degradation, it is paramount that the humans of tomorrow understand not only their impact, but are also taught the right information to adapt and survive in an increasingly complicated world.

Pedagogies of Environmental Education

EE is a growing field that can be used to address environmental problems. EE refers to organized efforts to teach how natural environments function and particularly, how human beings can manage their behavior and interact with ecosystems in order to live sustainably

(Smyth, 2006). It is a field of education that commonly intersects with many other disciplines such as biology, chemistry, physics, earth systems science, and ecology, as well as atmospheric science, mathematics, history, sociology, the fine arts, and more. As humans continue to use more of the earth's resources due to rapid population growth and development, our impact is becoming omnipresent. This has made EE a more crucial component of formal and informal education advents, as it has the potential to create informed citizens who understand their interactions with the natural world and strive to be stewards of their local ecosystems and the global environment.

The term environmental education is a highly debated topic, as it is a broad multidisciplinary field that can be taught in many different ways. Other terms similar to EE include “earth education” (Van Marte, 1990), “environmental learning” (Scott and Gough, 2003), “outdoor education” (McRea, 1990), and “sustainable education” (Santone, 2004). What separates these groups of thought is the methodology and pedagogies used to convey the knowledge as well as the different emphases placed on certain core concepts. Furthermore, many of these thinkers criticized EE as being entrenched in the values of the earth being filled with unlimited resources for human beings to exploit (Van Marte, 1990). It is important to understand when diving into the topic of EE that it is incredibly broad and can be taught in a multitude of ways.

In the book *Ecological Education in Action* Smith et al. write about a different way of teaching environmental learning; “The practice of ecological education requires viewing human beings as one part of the natural world and human cultures as an outgrowth of interactions between species and particular places” (Smith and William, 1999 p.3). This form of environmental learning addresses the criticism above by not viewing the natural world as separate from the human experience. Instead, ecological education holds the belief that the human experience is entirely influenced by the natural world. There are many benefits of this style of environmental learning when trying to teach about humans' relationship with nature. It provides important context for students to understand how their culture influences their world view. Ecological education can also help students grasp other cultural perspectives on nature and the environment, fostering a new world view. The ecological education style of teaching environmental learning follows the mission of this paper’s research in creating informed citizens who understand the interconnectedness of life.

Environmental education is usually taught through the pedagogies of place-based education (PBE) and experiential learning (EXL). PBE is defined as “forms of pedagogy that seek to connect learning to the local ecological, cultural, and historical contexts in which schooling itself takes place” (Elfer, 2011, p.1). Originally developed by Sobel (2005), this style of learning echoes the experiential educational theories of John Dewey (1938), who espoused that hands-on, place-based learning in their communities can make it easier for students to contextualize material and engage in the lessons, as it is more authentic, relatable, and relevant to the immediate surroundings of young learners. EXL is a closely related pedagogy to PBE, and is

simply the act of learning while doing. Immersive EE curriculums incorporate PBE and EXL to teach ecological topics in a way that makes the material much easier to grasp and contextualize.

Another important pedagogy is outdoor education (ODE), defined as a way to provide meaningful contextual experiences in both natural and constructed environments that complement and expand on classroom instruction (Woodhouse and Knapp, 2000 p.2). It is a broader term than EE, which can be taught in and outside of the classroom. PBE and EXL can both fall within the framework of ODE. ODE can have many positive effects by allowing students a change of pace from the traditional classroom setting which usually revolves around the use of printed and electronic media in lecture-based settings.

Benefits of Environmental Education

The benefits of environmental education are wide ranging and profound. Many studies have shown that EE courses can influence students' attitudes to make pro-environmental choices. Dr. Andrew Schneller's research study, testing the outcomes of experiential environmental learning on students in Baja, Mexico, found that EE as well as EXL can foster pro-environmental attitudes and lifestyle changes. His research compared an experimental group that participated in an EE course and a control group that did not take the course. Quantitative statistical analysis found no significant difference in changes to pro-environmental attitudes during the pretest and posttest. However, interviews with the students revealed more conclusive evidence of change. Shneller (2008) writes, "Although the quantitative assessment did not show statistically significant results in the environmental action construct areas, we ascertain through interviews that the course significantly instigated social and behavioral outcomes on various levels in regards to pro-environmental actions among students (and their families) from this year, as well as students from two years ago" (p. 163). Schneller (2008) continues by stating that he believes the lack of significant findings from pretest to posttest can be attributed to design flaws within the test. He explains that it is incredibly hard to design a survey that captures the complexity of these issues and the changes in students' attitudes. Continuing, he discusses that qualitative and quantitative data is paramount to understanding the outcomes of experiential environmental education, as they paint a fuller picture of how the lesson impacted the students. Interestingly, the study displayed students as a gateway for bringing environmental knowledge to other community stakeholders such as their families and friends. This finding highlights the complex impacts that environmental education can have within a community and that the positives impacts can be on more than just the students themselves. His findings show that to truly measure changes in students' attitudes, interviews as well as surveys or tests are important (Schneller, 2008).

Kimiti Richard Peter et al. (2013), discuss the benefits of EE in a research study of Kenyan students. In the study, Peter et al. (2013) found that teaching environmental education had widespread impacts on students and community action, in regards to many different activities. Teachers interviewed at the end of the study explained that they noticed community

members shifting from using chemical fertilizers to organic manure. Almost 90% of participants interviewed in the study explained that they now had a better understanding of the importance of reducing soil and water pollution (Peter et al., 2013). Furthermore, participants gained a better understanding of how certain chemical compounds such as leaded gasoline and carbon monoxide affect their health and the health of their community. The study concludes that providing communities with environmental education allows them to better understand their impact on the natural environment and how to make choices that can reduce this impact (Peter et al., 2013). This study further highlights the importance of EE in fostering pro-environmental attitudes and behaviors, and how they can have widespread influences on the communities in which they are being taught (Peter et al., 2013).

Environmental Education in Schools

Ecosystem Education

Elementary and middle school students cover a wide variety of topics within their science courses, such as ecology, genetics, human biology, evolution, earth and space, matter and energy, and history and philosophy in science (Littledyke, 2008). Environmental education is highly relevant throughout many of these topics. Nonetheless, for years educators have often left environmental themes out of the curriculum. Food webs are a basic step in the teaching of ecology, showing the interconnectedness and interdependence of life. This is especially pertinent to consider when discussing human-animal interactions, due to human dietary patterns and how they have implications for the welfare of animals and ecosystems (Littledyke, 2008). Through the creation of food webs, students begin to understand matter cycles and how recycling is natural in ecosystems and should be more explicit in the manmade world (Littledyke, 2008). By teaching energy flow hand-in-hand with matter cycles and food webs, one can "demonstrate the need for energy conservation and efficient energy use for sustainable systems, with implications for uses in society" (Littledyke, 2008, p.263). Another ecological topic often taught to elementary-aged students is the biological organization of animals. This includes, but is not limited to how they are defined by physical attributes, behavior, reproduction patterns, what role they play in an ecosystem and how they connect and interact with other animals. It is important to include the steps of individual, community, ecosystem, and biosphere (Littledyke, 2008). By teaching the concept of biodiversity, students are made aware of the need for many different kinds of species in an ecosystem in order for it to be successful. Biodiversity education also emphasizes the need for the conservation efforts of endangered habitats and species (Littledyke, 2008).

Evolution and Natural Selection

Numerous prior studies have concluded that natural selection and adaptation are some of the most widely misunderstood scientific topics (Kelemen et al., 2014). In addition to the issue of students having inaccurate knowledge on adaptation by natural selection, Kelemen et al. (2014)

also found a disturbing amount of teachers who misunderstood this concept. Therefore, it is essential to use different pedagogical methods when teaching this valuable concept to young students. Kelemen et al. (2014) completed a study regarding how young students in Boston, MA were able to grasp the concepts of adaptation by natural selection using picture books. This study was conducted with a control and treatment group, giving the treatment group a 10-page story book the authors created, using realistic pictures and factual narrative about an animal's evolution. After conducting and analyzing their results through pretests and multiple posttests, the authors concluded that "young children can grasp population-based logic of natural selection when it is presented in a basic, cohesive, comprehensive way" (Kelemen et al., 2014, p.899). This study emphasizes the importance of keeping young students focused by using visuals and tools that are captivating.

Bohlin et al. (2017) also highlights the multimedia principle when teaching science, "which suggests that people learn better from words and pictures rather than just words alone" (Bohlin et al., 2017, p.976). In addition to pictures and words, dynamic visualizations such as videos can supplementally aid in communicating aspects that may be difficult to understand using static visuals (Bohlin et al., 2017). Visualizations also aid in portraying events or processes that span large or short amounts of time (longer or quicker than young students may be capable of putting into context); in this case visual representations are key in fostering an understanding of evolutionary processes (Bohlin et al., 2017).

Climate Change

In modern times, human beings are dealing with an unparalleled rate of climate change, creating risk and uncertainty regarding the future (Stevenson et al., 2017). In order to battle the ever changing environment, it is vital to educate younger generations about climate change mitigation and adaptation (Stevenson et al., 2017). Nevertheless, it is important to approach these heavy topics in a sensitive manner when educating young children. Stevenson et al. (2017) "addresses what and how educators should teach and how students might be engaged to learn in preparation for an uncertain future arising from the risks and the human ecological impacts of climate change" (p. 1). When teaching climate change education, fostering an environment of creative and critical thinking is fundamental (Stevenson et al., 2017). Collaborative problem solving and cooperation help engage youth with this information in a productive manor (Stevenson et al., 2017). Climate change education ought to encompass a "social holistic learning process" which includes learning how to take action in your local community (Kagawa & Selby, 2010, p. 242). It is essential for students to explore the root of the problem as it is multifaceted, which can be achieved through discussion and debate (Stevenson et al., 2017). A key part of climate change education are the concepts of mitigation and adaptation, both at local and global levels (Stevenson et al., 2017). When discussing these ideas, some argue that individual actions are not as important to stress because climate change, at its core, is a systemic issue and requires systemic change (Gonzalez-Guardiano and Meira-Cartea, 2010). However true that may be,

Stevenson et al. (2017) believe that individual action is what inspires collective action and thus stimulates change.

As daunting as climate change is for the future, it is critical to highlight positive thinking in youth (Ojala, 2012; Stevenson et al. 2017). Although it is pertinent to discuss the degradation and demise of the natural environment due to anthropogenic climate change, climate change education should focus primarily on how to create a sustainable future and encourage hope in students (Ojala, 2015; Stevenson et al. 2017).

Environmental Education Online

Online education has become significantly more common in light of the Coronavirus pandemic. However, due to the current lack of published research about online environmental education since the start of the pandemic in 2019, this literature review instead includes research about online education prior to the pandemic. Online education goes by many names, such as e-learning and distance learning, but Sener (2011) defines it "as the use of online technologies for teaching and learning. This includes not only courses, programs, and other learning experiences that are delivered exclusively via online means, but also those that combine online and classroom delivery modes" (p.392). The combination of online and classroom education is referred to as hybrid learning (Sener, 2011).

Beneficial Outcomes of Online Instruction

The use of technology in academic settings has been highly controversial since its advancement in the past two decades, especially in regard to the education of young children. Stiles (2000) expresses the importance of social interactions in the context of learning, and fears that online learning will be less engaging, creating a more passive type of student. However, research suggests that the use of technology in academic institutions through computer-assisted instruction (CAI) offers an equal or greater learning opportunity (Aivazidis et al., 2006). Aivazidis et al. (2006) conducted research comparing the effectiveness of a traditional environmental education program to an online environmental education program in their ability to increase environmental knowledge and pro-environmental attitudes in 13-14-year-old students in Thessaloniki, Greece. The authors used pretest and posttest questionnaires in four groups, two control and two experimental. The two experimental groups were taught environmental concepts and ideas with a focus on rivers, one using traditional methods in a classroom setting and one using web-based instruction in computer labs with a distanced teacher (Aivazidis et al., 2006). The authors found that both experimental groups showed a significant increase in knowledge over the control groups, but the CAI group had a slight but significant higher boost in both knowledge and attitudes over the traditional experimental group (Aivazidis et al., 2006). The researchers also found a positive correlation between increased EE knowledge and more positive environmental attitudes. This correlation is not direct and only existed in the posttests, indicating

that the correlation requires higher EE knowledge and may have been influenced by other factors aside from their EE curriculum (Aivazidis et al., 2006).

Sener (2011) argues that online education should be more accepted into higher education, specifically for those in the natural resources field. According to Sener (2011), the natural resources discipline is already accepted and running successfully online at a number of higher education institutions, such as the University of Wisconsin and Oregon State University. There is also the Natural Resources Distance Learning Consortium (NRDLC), who commits to providing undergraduate- and graduate-level natural resources education, with 10 current active member institutions (Sener, 2011). Sener (2011) also found at least 25 other institutions offering online forms of natural resources education and environmental education to college students and adults. As of 2011, online education as a whole was experiencing steady growth, with 4.6 million participants in 2008 and a 5-20% annual growth rate leading up to 2008, with no sign of slowing down (Sener, 2011).

Online education is most highly revered for its inclusivity, lengthening an institution's reach far beyond its campus. Sener (2011) writes that it offers "improved access for all learners and new access to educational opportunities for previously unserved learners" (p.393). This fact has only become heightened due to COVID-19, during which significantly more students have participated in online learning. As of June 2020, 97% of college students had transitioned to online learning (Educationdata.org, 2020). As of August 2020, over half of elementary and high school students were exclusively attending online classes in Fall 2020 and just under 20% were partaking in hybrid learning (Liesman, 2020). Online learning has granted access to education for those who otherwise would be unable during the pandemic, such as immunocompromised students (Lumpkin, 2020). In other ways, however, online learning highlights inequality through discrepancies in technological access such as computers, tablets, and internet service (García et al., 2020).

Research has suggested that online learning is equal to or better than face-to-face learning, with benefits such as better discussions, quicker feedback, and an emphasis on students' wants and needs (Sener, 2011). Sener (2011) writes about the findings of the National Survey of Student Engagement, stating that, "online learners reported more engagement, intellectual challenge, and deep learning, while interactive technologies were also 'positively related to student engagement, self-reported learning outcomes, and deep approaches to learning'" (p.394). Online and hybrid education also support a handful of pedagogical innovations that are particularly valued in the education of natural resources, including concept mapping, critical thinking, and reflection (Sener, 2011). Hybrid learning courses have also been found to result in higher attendance in environmental science undergraduate courses (Sener, 2011).

A study conducted by Li et al. (2016) sheds light on three different types of interactions in an online learning environment—participant-participant, participant-content, and participant-instructor—explaining certain beneficial outcomes of each. The authors studied an online urban environmental education course offered to educators, analyzing these three different types of online learning interactions, measuring success in regard to four professional development skills.

These skills included the motivation to learn, the intent to apply learned information to their own lessons, the actual practice of adapting the information into their teaching, and the development of professional networks (Li et al., 2016). The authors found that participant-content interaction was the most essential in reaching their goals, followed by participant-participant, with participant-instructor interactions only resulting in the development of professional networks (Li et al., 2016). Students' interaction with the course content, encompassing a variety of formats such as videos and games, was vital in achieving student course satisfaction and a true motivation to learn and apply the themes of the curriculum (Li et al., 2016). The pedagogical approach of participant-participant interactions is not new to online learning and has achieved beneficial results in numerous previous studies, supported yet again in this research.

Although the research conducted by Li et al. (2016) focused on the education of instructors, the results could be extrapolated to other online learning settings to understand the value and weight of these three student-focused interactions. Multi-media participant-content interaction has been successful in promoting student motivation for a topic and likelihood to apply the ideas outside of the course. Both participant-content and participant-participant pedagogical approaches should be highly considered by online educators, particularly those in the environmental field, as to maximize positive outcomes in students.

Optimal Application of Online Education

Martin (2020) covers five main ideas to keep in mind in order to optimize online learning in the age of Coronavirus: instruction, content, motivation, relationships and mental health. The first is instruction: the need for instruction to be as well organized as possible, especially when students are learning new or difficult subject matter (Martin, 2020). In a traditional classroom, it is easy for a teacher to monitor whether students are grasping the content, and are able to adjust their instruction as they go. However, in an online environment, this is lost; there is a higher risk of losing learners if too much information is delivered too early (Martin, 2020). A way to reduce this stress is load reduction, which will keep lessons manageable while also providing feedback (Martin, 2020). The second idea is content: vet your online materials to ensure students are working with the best material possible (Martin, 2020). A good idea when teaching online is to look for online textbooks that are well targeted to the education syllabus (Martin, 2020). The third idea to optimize online learning in the age of Coronavirus is motivation: you need to keep students engaged by keeping their energy and effort up (Martin, 2020). Martin discusses what he considers to be the most important area of motivation in regard to online education: self regulation. The umbrella of self regulation encapsulates task management, persistence, and planning (Martin, 2020). Online learning creates a plethora of distractions, whether it is gaming, social media or internet rabbit holes (Dhawan, 2020; Martin, 2020). It is vital to keep students from these impulses, as hard as that may be. Martin discusses the importance of content and instruction in battling a lack of motivation (Martin, 2020). Moreover, frequently reminding students of these risks, printing hard copies, parental monitoring, and negotiating a school work/freetime timetable are other ways to avoid hindered motivation (Martin, 2020). Similarly,

Kufi et al. (2020) state how difficult it is for adolescents to stay focused for long periods of time, especially when they are in a remote setting. The authors emphasize the importance of group work, discussions, and cooperative learning as an effective tool to keep students focused (Kufi et al., 2020). The fourth idea is relationships: teacher-student and student-student relationships are an integral part of learning (Martin, 2020). It is important to keep things interpersonal when possible or applicable. Martin (2020) has observed that students seem to be adequate at addressing one another online and out of the classroom, so it is also important to emphasize the teacher-student relationship. Martin (2020) states that "teachers should over-communicate rather than under-communicate with the class" (p.2), using different modes such as email, video, blogs and class group chats. The last component is mental health: "if mental health suffers, learning usually suffers" (Martin, 2020, p.2). Support staff is not readily available to provide real-time assistance for the students in an online atmosphere. This is also an anxious time for many, so it is important to consider that some students may have lost loved ones and to provide appropriate support.

Challenges of Online Instruction

Online and hybrid learning has played a crucial role in promoting health and safety globally during COVID-19, and was even experiencing steady growth since 2008 far before the pandemic (Sener, 2011). It provides many benefits over in-person learning such as greater inclusivity, better dialogue, quicker feedback, and a deeper emphasis on the wants and needs of students (Sener, 2011; UIS, 2020). Nonetheless, online education also lacks the ability to offer certain benefits that in-person education provides, and poses new predicaments to academic institutions. The University of Illinois, Springfield (UIS) has written a comprehensive list of the outcomes of online learning, including numerous downsides. Firstly, despite the accessibility online learning provides to those who struggle to attend in person, be it due to health problems, packed schedules, etc., online learning also highlights discrepancies in access to technology and internet service (UIS, 2020; García et al., 2020). Similarly, computer-assisted instruction also creates a divide based on computer literacy in both students and educators, benefiting those with a greater comprehension of computer skills. Next, the ability for online courses to be a success is highly dependent on the educator's ability to teach in that setting—a skill that often requires training and preparation (UIS, 2020). In the case of COVID-19, courses transitioned from in-person to online very quickly, providing little to no time for this necessary training. According to both UIS (2020) and Kufi et al. (2020), online learning poses the greatest difficulties for younger students, as educators have struggled to create truly successful cooperative learning situations for this audience in a remote setting. In addition, the online education of young children places greater responsibility on parents and guardians during this time, as they are left with the task of ensuring their children are continuing to pay attention and receive the in-person, individual help they may require (Kufi et al., 2020). Lastly, online learning may provide a positive academic environment for many students, but it often requires a different set of skills than traditional learning. UIS (2020) writes, "In order to successfully participate in an online program, students must be well organized, self-motivated, and possess a high degree of time management skills in

order to keep up with the pace of the course" (p.1). The authors cite this as a reason that online learning is better fit for older students, posing far more difficulties to elementary-aged students who have a greater dependency on their teacher.

There are certain subjects and courses that, despite the benefits of online learning, would be most beneficial in an in-person setting, such as surgery, dentistry, and athletics (UIS, 2020). Similar to these subjects, environmental education benefits from experiential education approaches, such as field experience and outdoor learning (Jose et al., 2017). Soga et al. (2020) discuss the concept of the extinction of experience, or children's lack of time spent in nature, studying the relationship between it and negative attitudes towards nature and biophobia. The authors used questionnaires to understand the correlation between biophobia—measured in children's dislike, fear, disgust, and perceived danger of natural things (insects and spiders)—and different personal and environmental factors, such as environmental knowledge, time spent in nature, and level of urbanization at home and school (Soga et al., 2020). They conducted this study in central Japan, selecting a diverse range of students from over 50 different elementary schools, totaling 5,375 participants (Soga et al., 2020). The researchers found a significant negative correlation between an aversion to invertebrates and greater environmental knowledge and experiences. Although knowing the causality between these two factors would require further research, Soga et al. (2020) concluded that environmental education, particularly that which offers experiences and quality outdoors time to students, is important in fostering positive feelings and beliefs towards the natural world. In addition, the authors found that a continued extinction of experience could result in fatal repercussions on the natural environment, particularly in regard to biodiversity conservation (Soga et al., 2020). In this time of the Coronavirus pandemic, children's lack of experiential education and time spent in nature has only diminished further. The difficulty to social distance in urban green spaces has prevented many from getting outside, an issue that disproportionately affects marginalized groups (McKivigan, 2020). Though online learning is necessary to protect people's health and wellbeing, it is critical to find ways to incorporate experiences and outdoors time, especially for school-aged children, within online courses, particularly in those with a focus on the environment.

Ultimately, environmental education, especially from an early age, is crucial in fostering positive environmental attitudes and behaviors later in life (Jaus, 1982). Greater environmental knowledge has been found to have a positive correlation with more positive environmental attitudes (Aivazidis et al., 2006) and a negative correlation with biophobia (Soga et al., 2020). With that said, if computer-assisted instruction can further advance the scope of environmental education, especially during the Coronavirus pandemic when in-person learning continues to present pressing threats to health and safety, it is well worth the consideration from environmental educators (Aivazidis et al., 2006). Sener (2011) recommends educators ask themselves how online methods could enhance their courses, citing an example of a course on soils which is taught online but includes in-person labs to allow for hands-on experience. Growing acceptance of online and hybrid learning was on the rise pre-pandemic (Sener 2011),

and has now risen exponentially on a global scale due to the Coronavirus (Liesman, 2020). Professional environmental educators throughout the nation are adapting quickly to the challenges presented by the pandemic, working to shift towards online education in a meaningful and effective way. The North American Association for Environmental Education (NAAEE) provides online workshops and courses for environmental educators as to assist in this difficult transition. These webinars provided by NAAEE offer resources and guidance on how to teach environmental education in a safe way while maintaining the use of valuable pedagogies such as place-based and experiential education (NAAEE, 2020). With benefits such as greater inclusivity, better discussions, and higher engagement (Sener, 2011), it is possible that these technological modes of instruction could influence the face of education for a long time to come (Taparia, 2020).

METHODS

Research Overview and Program Description

To conduct this research, we partnered with a local private school in Saratoga County. To begin, we met with the primary teacher of our treatment group to better understand current and past environmental and science curriculums the students have had. Using this information, we created and taught 6 lessons based on the key themes in the students' current curriculum, with a goal of enhancing environmental knowledge and pro-environmental behaviors (Table 1). In addition to the students being taught the scientific discipline of chemistry this academic year, the current science curriculum theme was environment and change, in relation to biotic factors and ecosystem interactions, with a focus on animal diversity, plants, trees, and seeds. The primary teacher explained that the theme of the school for the year was equality, and therefore encouraged us to develop a lesson related to equality in the context of the environment. The lessons used pedagogies of PBE and EXL, as well as embodied learning, blended learning, and gamification. To make the course as relatable as possible, PBE was heavily utilized, with many examples related to the local ecosystems and the history of upstate New York. The lessons were multidisciplinary, combining history, biology, chemistry, geology, earth systems, ecology, sociology and the fine arts. Our curriculum consisted of 6 lessons taught over a 3 month span (January 2021 – March 2021).

Table 1
Online Ecological Literacy Curriculum

	Lesson One	**Lesson Two**	**Lesson Three**	**Lesson Four**	**Lesson Five**	**Lesson Six**
Lesson Title	Life Cycles Analysis	Animal Classification	Adaptation, Evolution & Natural	Watersheds & Wetlands	Dragonfly Pond Presentations	Advocacy & Letter Writing

			Selection			
Lesson Description	Students learned the life cycles of monarch butterflies, red-tailed hawks and spring peepers. Discussed how they are alike and different.	Students learned about the organization of animals into categories based on physical and behavioral traits. Discussed vertebrates such as mammals, birds, fish, reptiles, amphibians, as well as invertebrates.	Students learned about adaptation and evolution. Discussed topics such as Darwarnism and gene inheritance. Discussed symbiotic relationships such as commensalism, mutualism, and parasitism.	Students learned about watersheds, runoff and wetlands.	Students continued to learn about watersheds, runoff, and wetlands.	Students briefly learned about the impacts of climate change. Students also read about two local issues in their communities--Karner blue butterflies and the Saratoga Greenbelt.
Lesson Activities	Powerpoint presentation with a guided note sheet and diagrams	Powerpoint presentation with guided notes and diagrams	Survival of the fittest bean game: students were randomly distributed different tools and had to scoop as many beans into a bowl using their tool, until there was one winner.	Dragonfly pond activity: students broke into five groups representing different stakeholders and designed five towns along a conjoined river.	Student presentations as a follow up to the dragonfly pond activity. Presented their dragonfly pond towns. Towns were lined up and students discussed impacts of the different towns. Groups reconveniened and discussed how they could change their town to reduce its ecological impact.	Letter writing activity to local officials about one of the two local environmental issues they read about.

Research Respondents and Setting

This research took place in Saratoga Springs, New York, a city with a population of just over 28,000 citizens (U.S Census Bureau, 2019). Research was conducted in the 5th grade science classes of two private elementary schools, one as a treatment group and the other as a control group. The treatment group class contained 15 students.

The control group, who took pretests and posttests but were not taught the EE curriculum, consisted of another 5th grade science class at a comparable school, not engaged in an online environmental education curriculum. This class was comprised of 23 students.

The treatment group students along with their primary teacher were located in the classroom together, while us teaching the curriculum taught over Zoom, as we were not permitted to attend in-person due to COVID-19 restrictions in the school.

Methodology and Research Questions

This mixed methods research was based on the case study approach, the nature of which is to analyze the experiences and changes of a person or group of people over a set period of time (Yin, 2018). The purpose of this research was to add to the body of research about environmental education as a whole and delve into the newly present intricacies of online learning and EE in the time of COVID-19.

The overarching research questions that guided this research were:

1. What are the outcomes of an online environmental education curriculum on the pro-environmental knowledge, attitudes, and behaviors of elementary school students?
2. To what extent does online learning present challenges and opportunities as an effective pedagogical tool in the context of environmental education for upper elementary school students?
3. What pedagogical tools within online learning do students and teachers find to be the most effective in enhancing pro-environmental knowledge, attitudes, and behaviors?

Quantitative Instrumentation

In order to measure student environmental knowledge before conducting the lessons, it was necessary to create and conduct an environmental knowledge pretest. We created a 24-question knowledge test, which included multiple choice, fill in the blank, and open-ended questions, and incorporated themes such as animal diversity, animal classification, ecosystem interactions, animal/human interactions, and Saratoga ecology—all main themes of the fifth grade curriculum we created and taught. The questions were designed to specifically adhere to the six-lesson curriculum which was used in this study.

In order to create these questions, we used several model environmental literacy questionnaires, altered to fit the topics we would be covering in our online lessons. The

knowledge pretests and posttests were also later edited for clarity and content in accordance with the guidelines suggested by Creswell (2016). Pretests were distributed to both the control group and the experimental group in January 2021, within the same week of one another, before any environmental education was taught to the treatment group as a part of this study. Posttests were distributed to both groups two-weeks after the curriculum was taught to the treatment group. The knowledge pretests were aimed to assess the students' pre-existing environmental knowledge, and the posttests were used to assess a change in environmental knowledge in both groups.

Qualitative Instrumentation

In order to triangulate our data sources and methods (Creswell, 2000), semi-structured interviews were conducted to better understand the perceived effectiveness of the curriculum and changes in students' pro-environmental behaviors at school and at home. Two focus group interviews were conducted with treatment group students, one semi-structured interview was conducted with the primary teacher, and two semi-structured interviews were conducted with treatment group students' parents. Interview questions included topics such as the students' environmental behaviors at home, the degree to which students discussed curriculum topics outside of the classroom, and the students' overall experience with the online ecological literacy curriculum. All interviews were recorded using a digital voice recorder.

The semi-structured interviews with treatment group students took place in two focus groups, splitting up the entire class of 15 students into a group of 7 and 8. This focus group as well as the interview with the primary teacher were conducted by a third party, who did not help teach the curriculum in any way, and did not previously interact with the students, so as to reduce bias and reactive effects from the interviewees (King and Horrocks, 2010). The parent interviews were conducted via Zoom and lasted approximately 25 minutes.

Quantitative Data Analysis

The quantitative data from both the pretests and posttests were analyzed using a t-test and a non-parametric Wilcoxon sign ranked test, a nonparametric test procedure for the analysis of matched-pair data. This compared changes in means both between students within their cohort, and changes in means between the control and treatment groups.

Qualitative Data Analysis

The interviews were transcribed through a combination of Zoom transcription services, Otter.ai, and manual transcription methods. The data from the interviews was then organized by key questions, phrases, and ideas to prepare for analysis. This information has been presented in the results in the format of representative quote charts and narrative quotes (Table 2 and Table 3).

FINDINGS

Quantitative Findings on Environmental Knowledge

Using an independent samples t-test at pretest, there was no significant difference found between the knowledge scores of the treatment and the control groups (p = 0.662). At pretest the treatment group scored an average of 14.75 and the control group scored an average of 13.93 out of 35 total possible points.

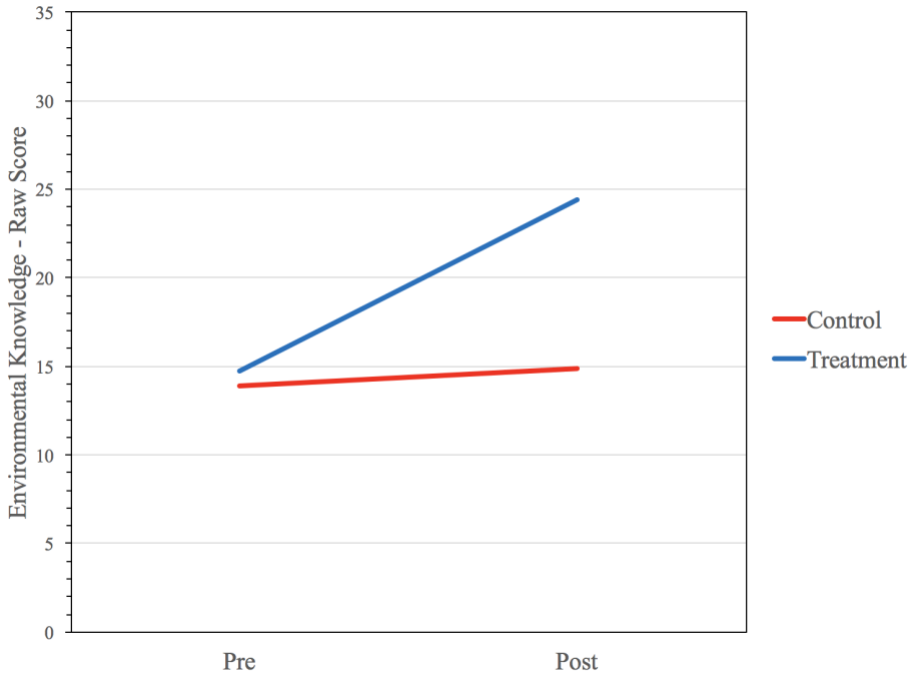

Figure 1. Environmental knowledge scores pretest vs. posttest

At posttest, utilizing a Wilcoxon signed rank test, a nonparametric test procedure for the analysis of matched-pair data, we found that the difference within both the treatment and control groups was statistically significant. Out of 35 points, the treatment group scored an average of 24.38 points (Z=-3.069, p<0.002148), and the control group scored an average of 14.87 points (Z=-1.234, p<0.217203). Based on the Wilcoxon signed rank test p-value scores, the treatment environmental knowledge scores significantly improved and control group scores did not. The treatment groups environmental knowledge scores improved by 65.3% (9.63 points) while the control only improved by 6.7% (0.94 points) (Figure 2). The improved environmental knowledge score in the control group can likely be attributed to increases in knowledge within and outside of the classroom, despite the fact that they were not treated with the environmental education curriculum. Using an independent samples t-test at posttest, we found the treatment group's

environmental knowledge scores statistically differed from those of the control group (p=0.0000109).

Qualitative Findings

Advantages and Challenges of Online Environmental Education

During the focus group interviews with the treatment group, students discussed their experience with online environmental education. The largest takeaway was the students preference for in-person education. Parents and the students' primary teacher corroborated these opinions by discussing the limitations of online student-teacher relationships and content communication. Students explained that they enjoyed powerpoint presentations in comparison to in-person writing on the whiteboard. (Table 2). Though the students had positive things to say about their online environmental experience, it was clear that there was a preference for in person education. In addition, the primary teacher felt that the students struggled with parts of the PBE element of the curriculum, which she attributed to the class taking place online.

> Teacher: The place based aspect didn't connect as well as I would have liked. I think it still felt a little apart. If they had the opportunity to maybe go out into the field and understand, you know, even just visiting the sewage treatment plant, that might have stuck a bit more. It was harder, but when they did the dragonfly pond piece of it, they could understand that pollution starts in one place and it affects everything in the watershed.

Parent and teacher interviews corroborated the student responses and student conceptual awareness:

> Parent 1: She [her daughter] would probably prefer in-person...but she didn't differentiate only being online...For this year, it was the best it could be.

> Parent 2: Whatever you did really connected with him, because he did say that he felt engaged in a way in this class that he wasn't in his in-person class, so however you were teaching it, the lesson was really conveyed in an interesting way.

> Teacher: Another thought I have about presenting virtually, is that maybe having pieces of it be taped so that students could watch at different times and then interacting or have it mostly be discussion after the fact...it might help slow down some of the lessons, and help kids absorb things.

Table 2
Representative Student Quotes About Online Environmental Education

Advantages	Neither Advantage or Challenge	Challenges	In Person Preference

I do like the slideshow because I thought it was really easy to see. I think even if they were like going to do it again in person [they should keep the slideshows]. I really like the slideshows because if they had been in person, they would have written it on the whiteboard, and they would not have had enough space to write it, so they'd have to erase some things, and it was easier with the slideshow.	I don't really find it difficult to have people on Zoom teaching us, there isn't really a difference, besides the fact that they're…on screen. So, it's the same as being in person, I found their teachings very valuable.	When it came to the videos, It was like it was really slow and hard to understand. It might be lagging or might freeze and you might not hear their instructions, but I think it still worked in that they got their point across	I think we would have gotten more done if they were in person. I think it could have been a lot better if they were in person, because they could get to know us better and they could see all of us, so they could call on any person who was raising their hand, not only the people they could see.

Awareness of Environmental Issues and Pro-environmental Attitude Changes

Through focus groups with the treatment group, multiple students expressed a greater passion for environmental issues as a result of the 6-part curriculum (Table 3). When the students' primary teacher was asked what she believed to be the biggest takeaway from the curriculum, she said, "Right away I'm thinking, 'we affect ecosystems.' And I think it really was the goal, so I think that was spot on." One student expressed a desire to protect the Saratoga Greenbelt, a local greenspace in their community, after learning about it and writing a letter to their representative on the subject. Another student expressed a greater level of care for the issue of pollution as a result of now understanding that it is a serious global issue that has impacts on the ocean, animals, and drinking water. Three other students echoed that thought, stating that they would like to study more about watersheds, runoff, pollution, and how they can have a positive impact on these issues (Table 3). After learning about the importance of wetlands, one student said:

> I have always been very interested in ocean and nature conservation… I'm really interested in figuring out if there would be ways to put on artificial wetlands in places where pollution could be flowing directly into open water where things could be harmed by it. So, that'd be something I'd be interested in figuring out, like if we could put artificial wetlands … in the estuaries so that any pollution flowing down rivers wouldn't get into the ocean.

Many students reported other issues that they have become more interested in and would like to study further as a result of this environmental curriculum, including climate change, survival of the fittest, local endangered species and public lands, and animal diversity (Table 3). Students showed signs of greater investment in issues, with one student stating:

> I learned about the Karner blue butterfly … the only butterfly I really knew was endangered was the monarch butterfly. But now that I know about the Karner blue Butterfly, it's just really interesting, and to see how/if they come back or if they don't.

Multiple treatment group students, the students' primary teacher, and the two interviewed parents indicated that students have spent time outside of class engaging with the issues they learned in the curriculum (Table 3). A few students stated that they chose to research environmental issues such as wetlands, runoff, and animal diversity on their own time, and have brought these discussions home to share with their parents, siblings, and friends. The students' primary teacher noted that the students discussed an activity they did in the environmental education curriculum about watersheds amongst themselves in their free time, which allowed them to engage with the material further. "They really connected with it… They loved it" stated the teacher. Both of the interviewed parents expressed that they believe their child will remain interested in the curriculum topics after the completion of the lessons. One of the students whose parent was interviewed has always been interested in the environment, so it is important to note that this passion may not have been a result of the curriculum, although the parent believes the curriculum gave her child tools to further her interest. The other parent stated that their child:

> In general does not like science, I think he just finds it kind of boring. But he said that this experience was—he liked science, he liked this part of the science class. He said this was more engaging and hands-on and interactive than other parts of his science class, so he definitely noticed that.

Pro-environmental Behavior Change

Numerous students expressed that they have made pro-environmental behavior changes as a result of this environmental curriculum (Table 3). Many students indicated that they have worked to reduce their water and electricity consumption, such as by turning the water off while they brush their teeth, taking shorter showers, turning off lights when they leave a room, and even working to vacuum more quickly to reduce electricity use. Other students expressed an interest in making positive changes to their environmental behaviors but making little progress thus far. One student indicated having trouble remembering to continue with his positive environmental behavior change, though he is passionate about the environmental issues he learned within this curriculum as well as those he has learned about on his own. He wants to continue to do better, which he indicated was further fueled by the curriculum. Two students expressed interest in writing letters to their public officials again in the future, which is an activity they did in the curriculum. One student said:

> I've never written a letter like that. But me and my sister and a few of our friends started a small organization [prior to the curriculum]. And we were considering ways to, like protect the environment… And writing the letter to public officials, it's one of the things we considered. So we were probably going to do it in the future. And [the curriculum], like, helped me with the idea to do that.

A few students also shared that they have always been relatively environmentally conscious, so have not made many changes to their lifestyle since the curriculum (Table 3). However, one student stated that although they have already taken pro-environmental measures at home such as recycling and reducing water consumption, he now has a greater understanding and appreciation for the work being done at home. One student's parent has noticed that recently their child has been a bit more proactive about recycling things around the house. Another student's parent shared that, since the curriculum, their child recently asked to buy reusable items for their pet, such as washable pee pads, to replace the disposable items they had previously been using.

Most and Least Meaningful Course Components

Through focus groups with the treatment group, students conveyed that the activity portions of the 6-lesson curriculum were their favorite parts. The three activities: the survival of the fittest bean game (SFBG), the dragonfly pond activity (DPA), and the letter writing activity (LWA), all resonated most positively with the students due to the inclusion of experiential learning. The students' primary teacher highlighted this during her interview, stating,

> It was...the interactive piece that they liked…[it] allowed them to talk about [the topics]. The overall acquisition of the information [was easier]. I think the vehicle for those lessons was dynamic.This activity they really connected with, every student was able to explain how humans can affect an ecosystem, which is awesome to see and a practical application of the information given to them [in the lecture].

The teacher felt that it was easier for the students to connect to the lessons when they had experiential learning components. Out of the three activities, the students found the DPA was above and beyond the most meaningful. From the two focus groups, almost all the students expressed that they had fun participating in it and enjoyed the freedom and creativity. One student explained "I really like the dragonfly pond activity, because, like everybody else said, it was really fun to design your own town." Another student explained that the DPA helped them grasp the concepts of watersheds and runoff by helping them visualize what they had just learned:

> I didn't really understand...when we were starting to learn about runoff and watersheds. I didn't really get it until we did the project with the towns [DPA], and then we lined them up, and then I really got it because [the other students] had the top [town] which polluted the water and it all moved down to the ocean. And then I really started to understand what we were learning.

Although the concepts of the watershed and runoff lecture were hard for the students to understand at first, the DPA allowed them to visualize many of those concepts and apply them in an experiential setting, which helped the content resonate (Table 3). Similarly to the DPA, the SFBG also allowed for the practical applications of the lecture material. One student explained:

> I also liked the survival of the fittest activity (SFBG). It was really hard to actually like, do it. But once you get the hang of it is really fun. It did make sense because, I mean chopsticks, spoon, fork they are all different, and same with the beaks, they all have their advantages and disadvantages.

Another student said, “Yeah it related because the material [tool] you were using was the bird beak basically.” Students also liked the competitive aspect of the SFBG and their teacher overheard them discussing different strategies for how to collect beans quicker. All in all, it was the activities that stood out as the most meaningful course components.

The least meaningful course components were the lecture-based lessons, and most specifically lesson 1: Life Cycle Analysis. Many of the students shared that they had already learned this information in previous classes and therefore found the lesson repetitive and boring. One student stated:

> I didn't really enjoy the life cycles that much. Because that one, we weren't even reading to collect notes, we were just listening to them talk. And then this writing notes about it and I found that kind of boring. Okay. I mean, it was still very informational and I liked getting that info. But I just felt like the way it was done or just like just listening to them tell us information and then taking notes on it was kind of boring.

The primary teacher also explained that the life cycle topic was one of the few they had learned in depth beforehand, stating, “They would have had life cycles to some extent...it is a big one that they do in younger grades, like they get the chicks and you know the tadpole observation and stuff like that.” However, when going over this lesson with the teacher prior to its implementation, she mentioned that starting with a subject that they have an understanding of may help them engage with the course material better in the long run. Although the life cycle lesson was boring for many of the students overall, it may have helped them quickly engage and feel comfortable with the curriculum material as well as offered a more indepth look at a topic they already understood.

> I felt like life cycles, we've known, I've known, how life cycles work for a while. I felt like I was kind of reviewing the life cycle unit in class, because I've done it like three other times in past grades. So I felt like it wasn't really necessary to have to go over life cycles again, although I did learn a couple of new vocabulary words.

Although most of the activities received positive reviews from the students, the LWA had a few negative takeaways. Most of the students shared primarily positive views of the activity, however their teacher explained that the PBE components of it struggled to connect, and the students found slight difficulty in writing a letter to a representative. Their primary teacher explained,

> Broadly they have an understanding that 'I could write a letter to make a change.' I think it was harder because they weren't given a specific 'ask' to the representative they were writing to. We had to work on that a little bit after to say, yes saying thank you is good, but what are you asking them to do? The hard part with that was that the local groups are doing a lot of great work so we kinda narrowed it down to what commitment you will continue to make. I would say that [the curriculum teachers] presented a nice way for them to reach out and make change but there was a little bit of a disconnect there.

Intergenerational Learning

Intergenerational learning (IL) was a particularly hard subject to qualify due to the nature and restrictions of this study. During focus groups with the treatment group and interviews with the students' parents and primary teacher, we concluded that most of the intergenerational learning happened between students and their families. One student spoke about sharing what they had learned in the lessons with their parent, "My mom came into my room while I was getting ready for bed. And when she sat down we ended up talking about animal diversity for hours." Two students tried to enlighten their younger siblings about positive environmental behaviors, with one stating, "I tried to save water by telling my sister not to take three hour long baths, and changing the water every single time it gets warm." Another student explained that she was excited to share what she had learned about butterflies with her grandmother, who is an avid butterfly enthusiast. She shared that she was happy this lesson came before the summer, as that is when she spends a lot of time with her grandparents. However, she explained that she had barely been able to see them as a result of the Coronavirus pandemic.

COVID-19 played a crucial role in decreasing interactions between people during this time, reducing the transfer of information between the students and their family members as well as others within their social circles. The students' primary teacher touched upon this when asked if she noticed any students sharing information with their parents, siblings or the other students at school. "Not that I have noticed, I think it is very early since we just finished, so not yet." Further research on the relationship between COVID-19 and environmental IL would be beneficial to make more definitive statements on the impact it has had.

Pro-environmental behaviors were also shared between the students and their family members. However, there were barriers that reduced this dissemination, most crucially a feeling portrayed by many students that their families already had pro-environmental behaviors and nothing more could or needed to be done. For example, one student stated, " I never really have to remind my parents or the rest of my family. We are the definition of an environmentally good family." Similarly, another student said:

> Well, for me, I haven't necessarily changed anything because I kind of already do...My family, we don't have that much to like [change], in our house, we already like do everything that we can, like we have a recycling bin, like, as big as the trash can. And we all care about not wasting things...not wasting plastic.

Further research is necessary to evaluate the impacts of a perceived ceiling effect on the intergenerational learning of pro-environmental behaviors.

Table 3

Representative Student Quotes by Topic

Most Meaningful and Least Meaningful Course Components	**Awareness of Environmental Issues and Pro-Environmental Attitudes Change**	**Pro-Environmental Behavior Change**	**Intergenerational Learning and Change**
I felt like the watershed and dragonfly experience was really interesting not only because it was like creative and fun, but also for the fact that we learned about how it affects things downstream. I have to agree. I really like the dragon fly pond activity, because, like everybody else said it was really fun to design your own town with like, a thing that you have to remember, like I know my group was the farmers we had to remember that we had to make sure that everything was in favor of our farm. We built all this stuff [in the dragonfly pond activity] not thinking about the effect that it would have on the environment, like in real life how people are kind of forgetting that it can have effect on our world. So eventually, after we had done all the stuff we were like, oh no! We're gonna completely mess up our universe.	What really got me started on the environmental stuff is Greta Thunberg. After learning about her, I got like freaked out about all the things I was missing out in the world. So then, the Skidmore students appeared, and it was like Greta Thunberg was the spark, they were the gasoline. They really got me going. I kinda want to look more into climate change. Because I want to help it. I mean, I was always interested in stopping it but [the curriculum teachers] kinda like reminded me of this. Something that made me kind of care about a new topic was in the letter writing [activity]. I knew nothing about the Saratoga Greenbelt, but I chose to write about it. And in researching, I learned a lot of things that were interesting. I learned [about]…the challenges and the threats and how to resolve them. So it's really interesting because	I turn off the water while I'm brushing my teeth. They [the curriculum teachers] told us about it… Because it conserves water… that was from the lessons with [them]. I know I haven't been leaving my room light on as much. And I knew we learned about that in one of the videos [the curriculum teachers] showed us… I wasn't very good at it [before] and now my room light isn't on as much. I have also been trying to take short showers. … I'll take a shower and then remember to do it after the shower, but I've already taken a shower. And then the next time I shower I still won't remember." So, at our house, we have always been quite environmentally friendly and focused on it. And after lessons, nothing really changed. But I appreciate the scope of what we're doing a little more at our house.	I told my mom a little bit about the dragonfly pond project...And I tried to tell my sister but I don't think she was listening...But I think my mom heard, understood some of what I said. I don't normally...feel like talking to my parents about stuff that happens in school. Unless it's something that I'm like, interested in. But every time we did the lesson, I would always tell them about it. And I would tell them, like, what we learned about and how interesting it was. And then I also told them I was sad that it was ending. So one night, my mom came into my room. And I was getting ready for bed. And so my mom just sat down on my bed. And I started talking. And I ended up talking about [the lesson topics] for like four hours.

Well, I like them all. But if I had to choose… my least favorite, it would be probably the life cycles. Because although it was all very, very interesting information. We were kind of just taking notes. And that is important. But I would like to use...you know, kind of like a project that's not based on notes at one point, at least.	…it's in Saratoga [the students' local town]. So it's interesting.		

CONCLUSION

In the time of the COVID-19 pandemic, environmental education has seen a required shift towards remote settings, overall reducing students' hands-on experiences and time spent outdoors. However, this study presents very uplifted results about the potential for online environmental education regarding environmental knowledge and pro-environmental behavior change. The results show a statistically significant increase of 65.3% in the environmental knowledge of the treatment group of students from pretest to posttest, whereas the control group insignificantly increased by 6.7%. In previous research, Aivazidis et al. (2006) also found that online environmental education has the capacity to significantly increase environmental knowledge in students, which in their case took place within 13-14 year old students in Greece.

In addition, the qualitative data, made up of interviews and focus groups with treatment group students, parents, and the primary teacher, indicates that students have worked to improve their environmental behaviors, with a handful of students truly reducing their water and electricity consumption. Students have also become more aware and passionate about environmental issues such as watershed conservation and climate change. In total, this online ecological literacy curriculum promoted age-appropriate advocacy such as writing letters to local officials, working to change one's individual behaviors, and sharing information with friends and family. Similarly, previous literature such as Schneller (2008) and Peter et al. (2013) has also found that EE courses can foster greater pro-environmental attitudes and behaviors in students.

Intergenerational learning was also a result of this curriculum, with treatment group students telling their families what they learned in school and advising their siblings on how to improve their water and carbon footprint. These findings align with those of Schneller (2008) and Peter et al. (2013), who found that EE and increases in environmental knowledge within one group in a community can cause a spread of information throughout the community at large. However, the primary teacher in this study believed that due to restrictions caused by COVID-

19, overall intergenerational learning may have been stifled as a result of students' inability to see more of their friends in person.

Although the lessons involved many PBE components, the students' primary teacher felt that these components may have been lost on the students as a result of the curriculum's online implementation. This was further displayed within the focus groups with treatment group students, as students were only partially able to share substantial information about how the lessons connected to local issues. This can likely be attributed to the lack of outdoor components within the curriculum, such as field trips or other experiential-based elements that would have allowed students to more easily connect the material to their current location. Additionally, most of the students and their primary teacher expressed a preference for in-person learning as opposed to online. They felt that although the lessons were informational and enjoyable, the online aspect of it took away from their ability to connect closely with the instructors. These findings differ from research done by Sener (2011), who found that online learning has offered better discussions, greater engagement, and deeper learning than in-person settings. However, Sener (2011) looked at the results of online education within higher education, which could explain the difference in our results. Ultimately, our study displays that online learning can be an effective tool for teaching environmental education; however, its use should be curtailed, only implemented when necessary.

This research also highlights the effectiveness of EXL at teaching environmental education online. All of the students found the hands-on, activity based lessons to be the most meaningful. Additionally, many students expressed that these EXL-based lessons helped them grasp the course material better. Students found lecture-based lessons the least meaningful, struggling to fully connect with the material. In their research, Li et al. (2016) also found participant-content and participant-participant interactions, involving more hands-on approaches, to be the most effective methods towards achieving higher motivation to learn and intent on applying learned materials outside of the classroom.

Additional research would be beneficial to expand upon this study's understanding about the impacts and outcomes of online environmental education. We recommend a study comparing a similar online and in-person environmental education curriculum, as to truly compare the different results of online versus in-person ecological education. In addition, we recommend similar future research to take place in public schools, as there are a number of different variables in that setting than in private schools that are important and valuable to research.

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